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Genetically Modified Crops' Technology and its Awareness among Smallholder Farmers in Nigeria

Abstract. Genetically Modified (GM) crops are crops modified through genetic engineering to improve their quality. Although safety concerns about genetically modified organisms (GMOs) are still being debated, the food security benefits have led to adoption by many counties. In Nigeria, where most farmers are uneducated and likely unaware of the agricultural technology, the government approved its first biotechnology crop for commercialization in 2018. Level of farmers' awareness is crucial to acceptance of GM crops, although; this has not been fully explored in the literature. Therefore, this study aimed to assess farmers' awareness for GM crops and the factors that determine their awareness in Oyo state, Nigeria, using primary data collected in 2018 with the aid of well-structured questionnaires from 242 smallholder farmers. Principal component analysis and Tobit regression model were used for data analysis. Results showed that farmers were aged 43 years with farm size of 3.57 ha, farming experience of 14 years and 11 years of education. Most farmers were male (71.90%), married (67.36%), not members of farmer groups (64.46%) and sourced their seeds from non-credible sources (85.12%). Most farmers (52.07%) had either not heard of or did not know of any benefits/costs of GM crops, hence; were not aware of GM crops. Factors that influenced awareness of GM crops were being a male farmer, years of education and source of seeds. The study concluded that increasing years of education and ensuring use of credible seed sources will increase awareness of the costs and benefits of GM crops among farmers.

Keywords: GMOs, smallholder farmers, awareness for GM crops, Credible seed sources, Agricultural technology

JEL Classification: O13, O30, O31, O33, O55

Introduction

Genetically Modified Organisms (GMOs) are organisms that have been modified by the application of recombinant Deoxyribo-Nucleic Acid (DNA) technology or genetic engineering which alters a living animal or plant genetic material (Yasin and Mulugeta, 2015). Hence, Genetically Modified (GM) crops have their genetic material, that is, DNA modified through non-natural means such as through the introduction of a gene from a different plant. Agricultural biotechnology is the foundation for conventional breeding, tissue culture and GM crops. Its history can be traced to the mid-1980s, with the initiation of China's National High-Tech program. Currently, more than 200 different GM crop varieties had been created worldwide (Fernandez-Cornejo *et al*, 2014). Commercial

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planting of GM crops started in the United States of America (USA) in 1996 and the adoption rate of GM has been the fastest in the history of agricultural technology (James, 2008). About 40% share in the global area planted to GM crops is in the USA and the largest proportion of GM crops with respect to soybeans, cotton, and corn are produced in the United States (USDA, 2016; Fernandez-Cornejo *et al*, 2014 and James, 2014).

The spread of GM crops has also been rapid and wide in the Americas and Asia (Bett *et al*; 2010). In 2012, GM crops were planted on 170 million hectares of arable land worldwide, with a global value of $15 billion for GM seeds (Fernandez-Cornejo *et al*, 2014). In 2016, the total acreage of genetically modified crops worldwide increased to about 185.1 million hectares (The Statistics Portal, 2017). Further, assessment of the global benefits from the cultivation of GM crops showed yield impacts in the direct farm income benefit calculations and also cost savings of reduced fuel use from less frequent herbicide or insecticide applications and a reduction in the energy use in soil cultivation (Brookes and Barfoot, 2018). Biotechnology has been widely acknowledged as a modern tool that holds the potential to improve agricultural production (Kagai, 2011). Global food security and nutrition is at the heart of GM crop development in addition to income generation and environmental protection for resource poor farmers (Eric *et al.,* 2014). It is widely considered globally, that GM crops are also one of the potential tools for increasing agricultural productivity.

In Africa, benefits from biotechnology and GM crops are expected to be large, especially given stagnating economies and food production, decreasing per capita food production and an expected increase in the number of poor people over the foreseeable future (Rosegrant *et al.,* 2001). The use of genetically modified (GM) crop technology in solving food security challenges and poverty reduction is an ongoing global debate, acceptance has been slow relative to other developing continents like South America and Asia. There is still concern on both the health benefits and problems of consuming GM crops. According to Medical News Today (2019), GM crops are believed to have a higher potential of triggering allergic reaction because they may contain genes from an allergen although, no such reports have been received by health authorities. Further, consumption of GM crops is believed to contribute to cancer development since the disease is caused by mutations in DNA, although the evidence to prove this claim is yet to be seen. There are also concerns that disease-resistance genes in food can transfer to cells in the body and make human beings resistant to drugs such as antibiotics, although, the risk is very low. The several health concerns of GM crops require more research to reach a conclusion. Hence, most African nations have ongoing research activities, particularly on staple foods. Only Burkina Faso, Egypt, and South Africa use commercialized GM crops, while Kenya, Nigeria, and Uganda have been slow in adopting the technology (Racovita*.,* 2013; Karembu *et al*., 2009). South Africa was the first country in Africa to release commercial GM crops (Eicher *et al*., 2006). The country's acreage cultivated to GM crops has been increasing by 2.6% while total acreage stands at about 2.73 million ha; mostly maize, cotton and soybean (Agaba, 2019 and Adenle*,* 2011). Farm income benefits of GM HT soybeans in 2016 accruing to South Africa was about $38.4 million while farm income benefits of GM IR cotton accruing to Burkina Faso was $204.6 (Brookes and Barfoot, 2018). These income gains are expected to have significant impacts on poverty and food security of farmers.

In Nigeria, there are no genetically modified organisms officially grown but with the new National Biosafety law enacted in 2015, Nigerian government officials publicly noted their interests in the commercialization of certain products such as cotton, maize and

herbicide-tolerant soybeans (USDA, 2016). Nigeria has adopted a National Biotechnology Policy designed to take advantage of the potential benefit impact in agriculture, industry, healthcare delivery and the environment (National Biosafety Management Agency, 2018). This policy instrument is proposed to give authority to the National Executive Organization to establish the necessary legal instrument and procedure to guide the implementation of the protocol, based on sound scientific, economic, social, cultural and ethical considerations. All the officially approved GM crops in Nigeria are under experimental fields. Another source of potential introduction of GM foods is through commercial importation of food containing ingredients from corn and soy (Subulade *et al*., 2007).

Adoption of genetically modified (GM) crops could contribute toward alleviating food insecurity in Nigeria (Yasin and Mulugeta, 2015), however, the preference of the farmers which are crucial to the acceptance of GM products have not been fully explored. The other subject for consideration include low awareness and a lack of information on GM crops. Many farmers are either not aware or less informed about GM crops (Oladele and Akinsorotan, 2007). Tegegne *et al.* (2013) affirmed that the information reaching the end users and producers of GM crops should be informative, easy to understand and user-friendly. Several reasons have been advanced for the reluctant and skeptical attitudes towards GMO-based technology, including a lack of public understanding of the science, difficulties in defining what GMOs are exactly, ethical or religious beliefs and little or no perception of the benefits that GMOs can bring (Comstock, 2002). People tend to fear what they don't understand and biotechnology is something a lot of people assume is too technical or too complicated to comprehend (Mahaletchumy and Brian, 2015). The importance of farmers acceptance in the deployment of GM technology is now widely accepted, and documented in a large body of research in many countries, although few in Africa (Kagai, 2011). Farmers are caught in the middle, they would like to use GM products, which are often cheaper and have other desirable traits, but they cannot do this if there is no substantial information about the price, dissemination and accessibility of the seeds in addition to other necessary information (Bett *et al*., 2010).

Although the debate is ongoing over the cultivation of genetically modified crops in Nigeria the opinion of the farmers seems to be lost in the debate; even though they are in a unique position to assess the product quality, viability and desirability. Farmers' opinions are not often considered when formulating policies related to agriculture in Nigeria and this has made many policies to fail even at inception (Ademola *et al.,* 2014). According to Bett *et al.* (2010), farmers are considered to be consumers of seed as a production input hence, their preference of one variety over another will be based on the utility they obtain from its attributes and this depends on their own socioeconomic characteristics, among others. Consumers' opinion is the key element of the GM debate. It is no use developing crop technologies if the consumers are not interested in the food that they produce (Kimenju *et al.*, 2011). Their first-hand knowledge could be useful in adapting the new technology to their real needs and could help to resolve the disputes between defenders and critics of GM crops more objectively (Tegegne *et al.,* 2013).

Although many studies (Ademola *et al.,* 2014; Okigbo *et al.,* 2011; Subulade *et al*., 2007) have been done on genetically modified crops in Nigeria, in the areas of food security, health and benefits. Similarly, several studies exist on the awareness of farmers in Nigeria on areas of innovative farmer-facilitations such as crop insurance and other agricultural technology (Kumar *et al.,* 2011, Ogwuche *et al*., 2016; Duhan and Singh,

2017). However; there is a dearth of research on the farmers' awareness about GM crops. The importance of farmers' awareness is critical to the assessment of agricultural seeds and crops. Hence, this study aimed to assess farmers' awareness of GM crops and the factors that determine their awareness in Oyo State, Nigeria.

Materials and methods

The study was conducted in Oyo state, southwestern Nigeria. It is one of the most populous states in the country with a population of 5,580,894 (NBS, 2012) and coordinates 8°00′N 4°00′E. It is an inland state with its capital city, Ibadan being the largest city in West Africa. Oyo state is bounded in the north by Kwara State, in the east by Osun State, in the south by Ogun State and in the west partly by Ogun State and partly by the Republic of Benin. The state covers approximately an area of 28,454 square kilometers. The dry season lasts from November to March while the wet season starts from April and ends in October. Average daily temperature ranges between 25 °C (77.0 °F) and 35 °C (95.0 °F), almost throughout the year. There are thirty-three (33) Local Government Areas in the state of which only six are urban. The major occupation of the people is farming particularly those in the rural areas. Some of the crops cultivated are cassava, yam, maize, plantain, cocoa, oil palm and orange trees.

Primary data was collected for this study with the aid of well-constructed questionnaires from small holder farmers in Oyo state. Data collection was carried out in 2018. Information was collected on the farmers' socio economics characteristics and their awareness on GM crops. A multi-stage sampling technique was adopted for this study. Firstly, the six urban local government areas (LGAs) in the state were screened out of the 33 local government areas since most small holder farmers are found in the rural areas. The second stage was the random selection of 5 local government areas (LGAs) from the rural local governments namely Kajola, Oluyole, Lagelu, Ido and Olorunsogo local government areas. The third stage involve the random selection of 5 wards from each of the selected LGAs. The fourth stage was the selection of one village out of each of the 5 wards selected. The last stage was the selection of maize farmers which was proportionate to the size of the villages selected. Although 250 respondents were surveyed only 242 maize farmers were used for the analysis due to incomplete questionnaires.

The data collected was analyzed using principal component analysis and tobit regression model. Principal component analysis was employed to identify the level of awareness for genetically modified crops among farmers in Oyo state. The evaluation of awareness was relative since it was based on the mean value of the number of farmers who were aware of GM crops. A question was asked if the farmers were aware of GM crops and whether they could state some benefits and/or costs of the agricultural technology. The study termed farmers that said they were aware and could also state at least one benefit and/or cost of GM crops as the farmers who were aware while others who had not heard of or did not know any benefit/cost as not aware.

$^2/_3$ of the mean of index was used to determine the level of awareness of the farmers

$$\geq {}^2/_3 \; of \; mean \; = 1 \text{(high awareness level)}$$

$$\leq {}^2/_3 of \; mean = 0 \text{ (low awareness level)}$$

The factors that determine the level of farmers' awareness for genetically modified crops in Oyo state was achieved through the use of tobit regression model. Following Kumar (2011), the model is specified thus:

$$T_i = w_0 + w_1 s_1 + w_2 s_2 + w_3 s_3 + w_4 s_4 + w_5 s_5 + w_6 s_6 + w_7 s_7 + w_8 s_8 + w_9 s_9 + \varepsilon_i$$

Where T_1= the level of farmers' awareness for genetically modified crops,
w_0 = intercept,
w_1... w_7 =parameters to be estimated,
s_1= years of education (years),
s_2= Marital status (married=1, otherwise=0),
s_3= Farm size (in ha),
s_4 = Farming experience (years),
s_5= income of the farmers (in naira),
s_6= gender of the farmers (male =1, female =0),
s_7= membership to farmers' group (Yes=1, No=0),
s_8=source of seed (credible source; ADP, research institution and other government agencies=1, non- credible source; market, friends, personal plot and others=0),
s_9=age of the farmers (years).

Table 1. A priori expectation for determinants of farmers' awareness for GM crops

S/N	Variables	Expected signs
1	Years of education	+
2	Marital status	+
3	Farm size	+
4	Years of farming experience	+
5	Gender	+/-
6	Membership to group	+
7	Source of seeds	+
8	Age of the farmer	-

Source: Authors' own research.

Results and Discussion

The description of the farmers' socioeconomic characteristics is presented on Table 2. The result reveals that most of the farmers (39.67%) were within the age range of 41-50 years while the mean age was about 43 years. This suggests that most of the farmers were still in their active ages and may be open to the new innovation of GM crops. This agrees with the result of Bayissa (2014) that most small holder famers are between 41-50 years of age. Moreover, over 70% of the farmers were male. This implied that farming was a male dominated activity in the rural area and agrees with the result of Aromolaran *et al*, (2017) that most farmers are male. Majority were also married (67.36%), indicating that they may have information of GM crops since most couples discuss and share new ideas with one another. Further, more than half (55.37%) of the farmers had farm sizes of between 1-5 ha while the mean farm size was 3.57 ha, showing that most farmers were small holders. With respect to the farm experience, however; the results showed that most farmers (44.21%) had over 10 years of experience, implying that they can make informed decisions about quality

of planting material and produce. The mean years of farming experience was about 14 years. This result is not close to Ojeleye (2018) that found farming experience to be about 20 years for small holder farmers. Furthermore, half of the farmers had between 7-12 years of formal education with the mean years of formal education being about 11 years. This suggests that majority of the farmers have above mere basic education and may therefore have a good understanding of the innovation and be disposed to GM crops. Further, most of the farmers (64.46%) did not belong to any farmer group. This may have negative implications for awareness of GM crops as farmers often get information on innovations from farmers groups. Finally, most farmers (85.12%) purchase their seeds from non-credible sources. These include seeds sales points that are not from the Agricultural Development Project (ADP), research institutions and other government agencies but rather from the open market, friends, farmers' personal plot and other of such sources. This may also have negative implications for the farmers' awareness of GM crops.

Table 2. Socioeconomics characteristics of farmers by GM crop awareness status

Variables	Frequency	Percentage	Mean	SD
Age (years)				
< 30	24	9.92		
31 – 40	79	32.64		
41 – 50	96	39.67		
>50	43	17.77	42.89	9.38
Gender				
Male	174	71.90		
Female	68	28.10		
Marital status				
Married	163	67.36		
Unmarried	79	32.64		
Farm size(ha)				
<1	68	28.1		
1 – 5	134	55.37		
6– 10	32	13.22		
Above 10	8	3.31	3.57	4.19
Years of farming experience				
<5	70	28.93		
5-10	65	26.86		
>10	107	44.21	13.72	10.83
Years of education				
0-6	48	19.83		
7-12	121	50.00		
>12	73	30.17	11.32	3.92
Membership of farmers' group				
Yes	86	35.54		
No	156	64.46		
Source of seeds				
Credible source	36	14.88		
Non-Credible source	206	85.12		

Source: field survey, 2018.

The awareness level of the farmers for GM crops is shown on Table 3. The results reveal that most farmers (52.07%) are not aware of GM crops. This could be due to the fact that most of the farmers do not source their seeds from credible sources where information on GM crops could be obtained. This agrees with Oladele and Akinsorotan (2007) that most farmers do not have information on GM crops.

Table 3. Awareness of GM crops among farmers

Awareness of GM crops	Frequency	Percentage
Aware	116	47.93
Not aware	126	52.07

Source: field survey, 2018.

The probit regression estimates for the determinants of farmers' awareness for genetically modified crops in Oyo state are presented on Table 4. The Log likelihood value is 57.18, LR chi2 (9) is 43.34 and Prob.>chi square is 0.00 which indicate that the model is statistically significant in explaining the independent variables, hence; the model fits the data. Gender was significant at 10% having a positive relationship with awareness of the farmers. This implies that the awareness of the farmers for GM crops increases with being a male farmer by 0.05%. This could be due to the fact that male farmers are usually more interested in new technologies than female farmers (Shauri *et al.* 2009). Hence the male farmers are more likely to make enquiries about new innovations and technologies in farming. They are also more likely to listen to news than their female counterparts. This result is in accordance with Xun *et al.* (2017) that being a male positively influence awareness level. Similarly, years of formal educational was significant at 1% and had a positive relationship with farmers' awareness for GM crops. Hence, the awareness of the farmers for genetically modified crops increases with an additional year of farmers' formal education by 0.07%. This is expected and is consistent with Erkie (2016).

Membership of farmers' group was significant at 10% and had a negative relationship with the awareness of genetically modified crops. This indicates awareness to GM crops increases with non-membership of a farmers' group by 0.07%. This is contrary to expectation as found by Kumar (2011) and Tanko and Opara, (2010) that membership of farmers' group has a positive relationship with the awareness for GM crops. However, the negative relationship could be as a result of most farmers not belonging to farmers' groups and hence relying on other sources for information on innovations. Finally, source of seeds shows a positive relationship with awareness level for the genetically modified crops. The result is significant at 5% and shows that as farmers get seeds from a credible source such as research institute, ADP and government agencies, probability of being aware of GM crops increases by 0.08%. This is expected as most credible seed sources share information and ideas about innovations and even organize trainings and meetings with the farmers. This is consistent with Tanko and Opara, (2010) that level of awareness for innovation increases as farmers' source planting material from credible sources.

Table 4. Tobit regression of awareness level for genetically modified crops

Variables	Coefficient	Std. Err.	T	P>t	dy/dx
Gender	0.05*	0.03	1.66	0.10	0.05
Age	0.00	0.00	1.58	0.12	0.00
Years of education	0.07***	0.02	3.92	0	0.07
Marital status	-0.02	0.03	-0.83	0.4	-0.02
Farmer experience	0.00	0.00	0.87	0.39	0.00
Farm size	-0.01	0.00	-1.46	0.15	-0.01
Farmers group	-0.07**	0.03	-2.51	0.01	-0.07
Source of seeds	0.08**	0.04	2.35	0.02	0.08
_cons	0.53	0.08	6.97	0	
/sigma	0.19	0.01			
LR chi2(9) = 43.34					
Prob > chi2 = 0.00					
Log likelihood = 57.18					

.***,**, * imply statistical significance at 1%, 5% and 10% levels, respectively.

Source: field survey, 2018.

Conclusion

The modification of crops through genetic engineering to enhance their value gave rise to Genetically Modified (GM) crops. The benefits of GM crops for food security have increased the adoption of the agricultural technology across many countries, although; safety concerns still abound in the literature. Nigeria approved its first biotechnology crop for commercialization in 2018 whereas most farmers are uneducated and may not be aware of the agricultural technology and consequently, may not be disposed to adoption. Hence, the aim of this paper was to assess farmers' awareness for genetically modified crops and the factors that determine their awareness in Oyo state, Nigeria. The study concluded that most of the farmers are not aware of genetically modified (GM) crops. It was established that the factors influencing awareness for genetically modified crops are gender (being a male), years of education, membership of farmers' group and source of seeds. Hence, awareness for genetically modified crops can be increased effectively by targeting male farmers who are educated while farmers should be encouraged to purchase their planting materials from credible sources such as the Agricultural Development Project (ADP), research institutions and other government agencies. Future research could also look into farmers' preferences for GM crops and their willingness to pay for the seeds.

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